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SEASONAL WETLAND / WATERFOWL HABITATS CREATED BY WATER RETENTION STUCTURES: A COMPARISON

January, 1995 through April, 1997

Final Report

Prepared By:
J. D. Maul and C. M. Cooper

October, 1997

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EXECUTIVE SUMMARY

Winter flooding of agricultural fields reduces erosion and results in less herbicide costs by eliminating the necessity of spring weed burn-down. When fields collect and slowly release storm runoff, they reduce downstream flooding potential. Properly installed pipe outlets also prevent scouring as they convey water into channels. Casual observation shows that waterfowl use flooded fields over winter months. The purpose of this study was to document beneficial use to waterfowl of agricultural fields which were flooded during the winter by the use of field-scale water retention/control devices. Investigators have shown that waterfowl use of flooded fields was part of a broader strategy of using multiple habitats. Our specific goals were to (1) document use of flooded fields by waterfowl and (2) increase understanding of waterfowl behavior as influenced by seasonal flooding practices. We addressed these goals by determining: (1) if there is an effect of habitat type on behavioral activity budgets of non-breeding waterfowl, with comparisons between moist-soil and flooded agricultural habitats, and (2) if the activity budgets of these species in flooded agricultural habitats respond to selected environmental or social variables.

The four species studied were green-winged teal (*Anas crecca),* northern shoveler (*Anas clypeata),* mallard (*Anas platyrhynchos)* and gadwall (*Anas strepera).* The response variables were waterfowl behaviors. Results include effects of habitat type and season on activities of non-breeding waterfowl. Gadwall feeding was greater in moist-soil wetlands than flooded rice while more time was spent resting in flooded rice fields. Time spent moving by northern shovelers and gadwall was greater in flooded rice than moist-soil. Time spent preening by mallards was greater in moist-soil habitats, and time that green-winged teal spent courting was greater in flooded rice fields than moist-soil.

Seasonal effects included more time fighting by northern shovelers and preening by gadwalls in late winter and more time moving by gadwalls in mid-winter than late winter. Interaction effects were detected for habitat and season on time spent preening and moving by northern shovelers and time spent courting by green-winged teal. A season by habitat interaction effect was also detected on percentage of time resting by gadwall and mallards. Main and interaction effects indicated that the role of flooded agricultural and moist-soil habitats are different for non-breeding waterfowl; however, this role does not remain constant throughout the entire non-breeding period.

Physical variables that were correlated with behaviors of shovelers and teal included temperature and light intensity. In addition, the number of conspecifics and flock size were social factors that influenced behaviors of these species. These results suggest that factors that may influence these variables, such as flooded area or timing of flooding, can be manipulated to maximize the function of flooded fields to non-breeding waterfowl.

Management efforts of flooded agriculture and moist-soil wetlands may need to be driven by different criteria. Results from this study suggest that the arrangement of these two habitats could be manipulated both spatially and temporally, in terms of availability. That is, stagger flooding of fields in time and distance from moist-soil wetlands and other natural wetland areas to optimize potential waterfowl habitat.

Keywords: agriculture, Anatidae, behavior, gadwall, green-winged teal, habitat, mallard, Mississippi Alluvial Valley, moist-soil impoundments, non-breeding waterfowl, northern shoveler, rice, slotted-board riser pipes, time-activity budgets, water control structures, winter flooding.

INTRODUCTION

The Mississippi flyway funnels migrating waterfowl from the prairie breeding grounds in Canada and northern United States to southern wintering sites. One particular migration corridor is along the Mississippi River. Many of the waterfowl species that travel this route spend the non-breeding season in the Mississippi Alluvial Valley (MAV) and on the Louisiana coast. This study focused on waterfowl in the MAV, specifically within the delta region of Mississippi.

The Mississippi Alluvial Valley contains vast areas of agricultural fields, predominantly cotton, rice, and soybeans (Delnicki and Reinecke 1986). Sporadically, this agricultural continuum is broken by rivers, National Wildlife Refuges, National Forests, and waterfowl management areas. Forested wetlands, which once dominated the Mississippi Delta, have been cleared and converted to agriculture over the past century and a half (Forsythe 1985).

Recognition that winter habitat is a key factor for waterfowl survival throughout the annual cycle began to increase in the early 1980's. Some waterfowl species spend eight months of the year on non-breeding grounds and during this time limiting effects on populations may occur (Weller and Batt 1988). Despite this knowledge, abundance of winter habitat is still declining, a direct result of continued forest clearing and draining of wetlands.

Waterfowl habitats in the Mississippi portion of the MAV are primarily cropland, oxbow lakes, moist-soil areas, fish ponds, and scattered forested wetlands (Reinecke et al. 1989). Historically, it is believed dabbling ducks once satisfied most of their habitat requirements within forested wetlands (Reinecke et al. 1989). Presently, many species

have altered their dependence on forested wetlands. As a result of long-term landscape changes, many ducks use several different habitats to meet their needs (Reinecke et al. 1989). For example, foraging in several different habitats has become necessary in order to fulfill nutritional requirements. Thus, availability of multiple habitats is crucial for winter survival of waterfowl.

Seasonally flooded cropland is a commonly used non-breeding waterfowl habitat in the MAV and presents both positive and negative value to waterfowl. Benefits of flooded cropland to waterfowl include: (1) waste grains are often highly available and concentrated (Ringelman 1990) and (2) less feeding time is needed in order to meet energetic demands, a result of high metabolizable energy content and availability (Baldassarre and Bolen 1994). Some disadvantages of flooding agricultural land include: (1) cropland does not provide much protective cover (Reinecke et al. 1989); (2) agricultural crops often lack essential nutrients (Baldassarre et al. 1983); (3) aside from soybean, *Glycine max*, most agricultural crops are a poor source of protein (Reinecke et al. 1989); and (4) crops tend to deteriorate much more rapidly than natural plant foods when submerged (Fredrickson and Reid 1988, Shearer et al. 1969); this may be the most significant factor limiting availability of agricultural food during the winter.

Waterfowl use of agricultural fields in general has been documented throughout the Mississippi flyway and other areas. Feeding flights to corn fields were observed in Texas agricultural areas (Baldassarre and Bolen 1984); mallard use of flooded fields was documented in Iowa (LaGrange and Dinsmore 1989); mallards were observed foraging in agricultural areas in Nebraska, and waste corn was found to be a primary winter food (Jorde et al. 1983); rice and soybeans were a common mid-winter food for

mallards (Delnicki and Reinecke 1986); and wet agricultural fields were found to be a preferred habitat type for waterfowl in northeastern Louisiana (Dell et al. 1987). However, these studies addressed habitat use and food resources of these habitats. In the present study we focused on activity patterns of waterfowl using agricultural fields in winter. Similar data are available for pintails wintering in California (Miller 1985) and Louisiana (Rave and Cordes 1993) but are absent for other species in the MAV. More than a half million hectares of rice, *Oryza sativa*, and soybean are planted annually in the MAV portions of Mississippi (Reinecke et al. 1989), making this a prominent component of the landscape. Seasonal flooding of these areas creates waterfowl habitat from which quantified data of waterfowl activities is needed.

Another habitat used frequently by non-breeding waterfowl is moist-soil/marsh areas, which provide naturally occurring seed producing plants. Natural aquatic plant seeds and leafy vegetation provide large amounts of highly digestible carbohydrates, fiber, and moderate quantities of protein. Seeds and tubers produced by these plants during the summer and fall have a very low decomposition rate when inundated with water (Fredrickson and Reid 1988, Shearer et al. 1969). The prolonged availability is valuable to waterfowl during mid-winter when many agricultural food sources have been depleted. Animal matter, which provides large quantities of protein and moderate amounts of carbohydrates, is abundant in moist-soil and marshes. Consumption of macroinvertebrates is observed during late winter before departure to breeding areas (Miller 1987). This feeding response to an increased demand for protein is required for breeding (Baldassarre and Bolen 1994).

All wetland sites studied during this project were created by water retention structures. Adjustable stand pipes were positioned within moist-soil wetlands to retain water within levees throughout the winter. Slotted-board riser pipes were installed within agricultural fields to allow retention of water after harvest and throughout the winter (Figure 1). Retention of water on fields provides several advantages to the landowner: (1) preventing erosion, including sheet, rill and gully erosion, (2) decreasing herbicide application costs, and (3) improving water quality of runoff.

The objectives of this study were to focus on flooded agricultural fields and moist-soil wetlands, two habitats that were intrinsically different but commonly used by non-breeding waterfowl, and determine whether they were exploited differently by waterfowl during the non-breeding season. Specifically, our goals were to (1) determine if non-breeding dabbling ducks used flooded agricultural habitats differently than moist-soil wetlands by comparing time-activity budgets and (2) identify effects of environmental and social factors on time-activity budgets within flooded rice fields. Time-activity budget studies including greater than two species are limited (Gaston and Nasci 1988, Thompson and Baldassarre 1991). Advantages of multi-species studies may prove particularly useful by minimizing observation bias among studies and collecting data during instances of similar environmental and habitat conditions (i.e., food availability, temperature, etc.). We focused on four species that were commonly found in both habitat types: green-winged teal (*Anas crecca*), northern shoveler (*Anas clypeata*), mallard (*Anas platyrhynchos*), and gadwall (*Anas strepera*). Data of waterfowl activity patterns within these habitats will be useful to managers as they

address, in part, several issues of the Lower Mississippi Valley Joint Venture (Loesch et al. 1994) of the North American Waterfowl Management Plan.

DESCRIPTION OF THE STUDY AREA

The study was conducted at the Yazoo National Wildlife Refuge (NWR) and adjacent sites, located in the southwestern section of Washington County, Mississippi (Figure 2). The refuge is approximately 8 km east of the Mississippi River and 12.9 km west of Hollandale. It encompasses about 5,050 ha of bottomland hardwoods, green tree reservoirs, cypress swamps, lakes, moist-soil wetlands, and agriculture. Swan Lake encompasses most of the north section of the refuge and contains several hundred hectares of permanently flooded cypress stands. The major drainage system for the refuge is Steel Bayou which is located along the eastern perimeter of the refuge. Lake Washington spans almost the entire length of the refuge and is located about 1 km west of the refuge.

Data were collected from flooded rice fields and flooded moist-soil wetlands within the northwest quadrant of the refuge (Figure 2). The two study areas were approximately 0.81 km from one another and were separated by Silver Lake Bayou, a greentree reservoir, a cypress swamp (part of Swan Lake), and a portion of a large rice/moist-soil wetland (Pryor Impoundment).

The non-hunted moist-soil complex, Cox Ponds, is a series of 16 relatively small adjacent impoundments formerly used as commercial fish ponds. They ranged in size from 0.9 to 9.8 ha and provide 97.9 ha of moist-soil habitat to waterfowl when completely flooded. Ten moist-soil wetlands were often used by dabbling ducks and ranged in depth from 10 cm to 75 cm. All impoundments were initially flooded by water

pumped from nearby wells and subsequent water level fluctuations were a result of evaporation and accumulating precipitation. The moist-soil wetlands were dominated by water-milfoil (*Myriophyllum* sp.), smartweed (*Polygonum* sp.), pondweed (*Potamogeton* sp.), arrowhead (*Sagittaria* sp.), false-loosestrife (*Ludwigia* sp.), and algae (Beal 1977). Panic grasses (*Panicum* sp.) were common on most levees. All vegetative growth resulted from germination of natural seed banks.

The 135.4 ha non-hunted agricultural study site was located along the north perimeter of the Yazoo NWR. Several field sections at this site were inundated by precipitation during the study period and slotted-board riser pipes were used to retain water. Positioned at the lowest part of the field, these structures retained runoff and were manipulated to hold rainwater to desired levels. Manipulation of two structures located in the south and east edges of these fields resulted in approximately 71 ha of flooded rice, ranging in depth from 5 cm to 40 cm. Rice fields were not tilled after harvest and waste grain and crop stalks were present. Algae were present in flooded sections of fields towards the end of the study cycle (March).

METHODS

Waterfowl time-activity data were collected from October 1995 to March 1997 from each habitat type using a 15x-40x zoom lens scope and 7x35 binoculars. Numbers, species, and gender were recorded. Behavioral budgets of waterfowl were determined from blinds by scan sampling (Altmann 1974). Observations began at the edge of a flock, and the scope was shifted across the flock and the instantaneous behavior of each bird encountered was recorded on hand tabulators. Waterfowl behaviors were divided into seven categories (Paulus 1984): (1) feeding (tipping and

surface feeding), (2) locomotion (flying, swimming, and walking), (3) resting (sleeping and loafing), (4) comfort (preening movements and self-maintenance), (5) alert, (6) courtship (pre-copulatory displays, post-copulatory displays and copulation), and (7) agonistic (chasing and bill threats).

Observations were made from 30 minutes prior to sunrise to 30 minutes after sunset for each sampling day. Each day of observation was divided into three equal blocks of time, morning, mid-day, and late afternoon. Furthermore, each block was divided into 15 minute periods of which six were randomly chosen for scan sampling (Gaston and Nasci 1989), resulting in a total of eighteen scanning observation periods per sampling day.

The data for the six scanning periods within each block were averaged, resulting in a time budget estimate for each of the three blocks within a day (morning, mid-day, and afternoon). To avoid percentage bias, blocks that contained less than 100 individual observations of each species were not included for analyses. Months were grouped in pairs to create three seasons during the non-breeding portion of the year, consisting of early winter (October/November), mid-winter (December/January), and late winter (February/March). Subsequently, early winter (October/November) was excluded from the model since agricultural fields did not begin to accumulate water until mid December; thus, a habitat comparison was not possible.

A three-way factorial analysis of variance was used to test effects of time of day, season(months), habitat type, and their interactions on individual behaviors of each of the four species from December 1995 to March 1997 (General Linear Models procedure, alpha=0.05) (SAS Institute Inc. 1985). Habitat type and season were tested

at two levels each and time of day at three levels. Data on activity budgets were represented by percentage of time spent performing each activity, and raw data were arcsine transformed to meet normality assumptions (Zar 1984). Treatment combinations had unequal numbers of observations; thus, SAS GLM (Type III) analyses were performed (Milliken and Johnson 1984). Each block within a day was a sample and sample sizes for each species were: green-winged teal (N=49), northern shoveler (N=53), mallard (N=34) and gadwall (N=39).

Air temperature, percent cloud cover, light intensity, waterfowl flock size, percentage of conspecifics within the flock and number of conspecifics, were recorded during each behavioral observation period (each scan sample) within flooded and averaged for each block. Light intensity was measured with a light-intensity meter (Environmental Concepts LIM 2300) and cloud cover was estimated. Pearson's correlation analyses (Jandel Scientific 1994) were used to determine relationships between environmental and biological variables and behavioral activities of the four species in flooded rice from December 1995 to March 1997 (alpha =0.05).

Preliminary water quality data were collected from a selected subset of five moist-soil wetlands and five flooded agricultural fields on the Yazoo NWR. We recorded water temperature, pH, dissolved oxygen, conductivity, and salinity using a YSI model 3800 water quality meter and filtered ortho-phosphates and total phosphorous following APHA (1992) guidelines. These parameters were sampled once each month between January, 1996 and March, 1996 and twice each month between December, 1996 and March, 1997. Total solids, dissolved solids, suspended solids, ammonia, nitrate, total chlorophyll, total coliforms, and enterococci levels were

measured twice each month from December, 1996 to March, 1997 following APHA (1992) guidelines. Hydrotrack well sensor modules (Stage recorders) were installed at the lowest points within the study rice field and a selected moist-soil wetland to record stage levels every 36 minutes from 19 December, 1996 through 16 April, 1997 from which weekly means were calculated. Reported water depths do not represent levels found in sections of the habitat that waterfowl commonly used; rather, the data is presented to show fluctuation over time.

Qualitative sampling of macroinvertebrates and available seeds were conducted sporadically throughout the study period by dip-net sampling. Most often, invertebrate sampling was conducted at locations in moist-soil wetlands and flooded rice where ducks were observed feeding extensively. Three sweeps were collected within a 3 m radius of feeding locations. Each dip-net sweep collected the top 2-3 cm of sediment. All samples were placed in plastic jars and immediately preserved and stained with an ethanol / rose bengal solution. Samples were sorted in the laboratory using mesh screens with openings ranging from 0.72 to 4.0 mm^2.

RESULTS

Temporal use of habitats within the study area, determined from weekly censuses, varied among species. Between years, the pattern for each individual species was similar. Mallards were abundant beginning in October through December and were often observed in large nocturnal aggregations in several different habitat types on the Yazoo NWR, usually about 30 minutes prior to sunset. After December, the large nocturnal aggregations ceased, and most mallards were observed in small groups and pairs. Gadwall were more abundant in forested wetlands and cypress

swamp areas during mid-winter (Dec-Jan), shifting use to flooded agricultural fields and moist-soil wetlands during late winter. Northern shovelers were most abundant within the study area during late winter (Feb-Mar). This influx of northern shovelers occurred on the Yazoo NWR during both study years (1995-1997) and may be a result of latitudinal shifts of wintering populations i.e. numbers from lower latitudes moving northward. Green-winged teal were often observed in large congregations during both mid-winter and late winter in both flooded rice and moist-soil wetlands. Mallards and green-winged teal were not likely to remain in a single location during the diurnal period in mid-winter. Often, ducks would arrive at sunrise and depart within several hours, likely sampling habitats to locate areas of high concentration and availability of food. However, during late winter, most ducks in both moist-soil wetlands and flooded rice fields remained for most of the day.

Water Quality and Invertebrates:

Mean water depth of the flooded rice field fluctuated less than 10 cm between 20 December, 1997 and 7 March, 1997 (Figure 3). After the first week in March, boards were gradually removed resulting in water level declines. The flooded rice field was expansive and areas that ducks used ranged in depth from 5 to 40 cm. Mean water depth of the moist-soil wetland gradually increased throughout the winter, then stabilized at the beginning of March (Figure 3).

Mean water temperature was greater in flooded agriculture than moist-soil wetlands during both years (Table 1) while wetlands tended to be slightly more basic than flooded fields. Means of water quality parameters were calculated for each habitat during both years of the study (Table 1). Mean suspended and total solids were greater

in flooded agricultural fields than moist-soil wetlands as well as mean chlorophyll, coliforms, and enterococci levels.

Macroinvertebrates were common in the moist-soil wetlands, particularly those wetlands with established aquatic vegetation. Commonly encountered invertebrate families included Corixidae, Chironomidae, Notonectidae, Planorbidae (Gastropoda), and Decapoda. Invertebrates were less common in flooded rice and consisted of Chironomidae, Ceratopogonidae, and Curculionidae; however, oligochaetes were frequently detected within dip-net and soil samples collected from flooded rice during the last month of the study (March, 1997). In addition, rice was found in samples collected from flooded fields during both mid-winter and late winter.

Time-activity Budgets:

The most common activity for all treatment combinations for both green-winged teal and northern shoveler was feeding (Table 2 and Table 3). The most common activities observed of mallards were feeding and resting. During several observations, resting activities were dominant, particularly during late winter in flooded rice habitat (Table 4). Teal, shovelers, and gadwall spent the greatest percentage of their time feeding; however, percent time resting was greater for gadwall than teal and shoveler (Table 5).

Gadwall and green-winged teal spent more time in courtship activities than northern shovelers and mallards (Figure 4), and gadwall and mallards spent more time alert than green-winged teal and northern shoveler. For both habitat types, mallards spent the least amount of time feeding of all four species studied (Figure 4). Activity patterns between season resemble those found between habitat type (Figure 5).

Although there were no significant effects of season on percentage of time performing feeding activities, feeding levels decreased for mallard and northern shoveler and increased for green-winged teal and gadwall between seasons.

Main Effects on Waterfowl Activities:

Several significant main effects were detected for all species with the three-way ANOVA (Table 6). Habitat had an effect on courtship activities of green-winged teal. Teal spent more time courting in flooded rice fields than in moist-soil wetlands (Table 7) and (Figure 4). Northern shovelers spent more time resting in flooded rice fields than moist-soil wetlands and percentage of time fighting (agonistic behavior) was greater in moist-soil habitats than flooded rice fields. Seasonl effects on activities of northern shovelers included more time fighting during mid-winter than late winter (Table 8 and Figure 5).

Mallards spent more time feeding and less time resting in moist-soil wetlands than flooded rice fields (Table 7). Time spent fighting (agonistic) was greater during mid-winter than late winter and more time was spent courting and alert during morning than mid-day and late afternoon. Feeding and agonistic activities of gadwall were greater in moist-soil wetlands than flooded rice. Gadwall spent more time resting in flooded rice fields than moist-soil wetlands (Table 7).

Interaction Effects:

Several two-way interaction effects were detected, most of which were seasonal and habitat interactions (Table 6). All other two-way interaction effects included habitat X time of day. Time spent courting by green-winged teal declined between mid and late winter in rice fields but increased slightly in moist-soil wetlands (Figure 6). Interaction

between season and habitat was also detected for alert behaviors of northern shovelers. Time spent alert by shovelers decreased in moist-soil wetlands between mid and late winter, but increased in flooded rice fields during the same period (Figure 7).

Four interaction effects were detected for activities of mallards. Feeding time was similar in rice fields and moist-soil wetlands during mid-winter; however, in late winter, mallards spent more time feeding in moist-soil wetlands than flooded rice (Figure 8). Resting activities were also similar during mid-winter but percentage of time resting increased in rice fields and decreased in moist-soil wetlands during late winter (Figure 9). In addition, mallards spent more time preening in moist-soil than rice in mid-winter but in late winter, preening time was greater in rice fields than moist-soil wetlands (Figure 10). A habitat by time of day interaction was detected for time spent moving. Mallards spent more time moving in the late afternoon than morning and mid-day while in moist-soil wetlands. In flooded rice fields, mallards spent more time moving in the morning and as the day progressed, less of their time was allocated to this activity (Figure 11). A season by habitat interaction effect was detected for feeding activities of gadwall (Figure 12). Percent feeding time of gadwalls decreased in moist-soil wetlands between mid and late winter and increased in flooded rice between seasons.

<u>*Environmental and Biological Variables:*</u>

Time spent moving by green-winged teal was negatively correlated with temperature and light intensity, while comfort (preening) was positively correlated to temperature (Table 9). Locomotion of teal was negatively related to flock size, percentage of teal present in the flock, and the average number of teal present. Percentage of time spent feeding was positively correlated to the percentage of teal

present and percent time performing comfort activities was positively related to flock size.

Negative relationships were detected between time moving by northern shovelers and temperature, flock size, and the number of shovelers present. Feeding activities were also negatively correlated to the number of shovelers and the percentage of shovelers in the flock. Time spent resting by shovelers was positively correlated with light intensity, temperature, flock size, percentage of shovelers in flock, and the average number of shovelers in the flock. Time spent courting by shovelers was positively associated with the percentage of shovelers in the flock and the average number of shovelers present in waterfowl aggregations.

Time spent resting by mallards was negatively correlated with the average number of mallards observed in waterfowl flocks in flooded rice fields. Gadwall locomotion was negatively correlated with temperature and percent of time alert was positively correlated to the percentage of gadwall in waterfowl flocks.

DISCUSSION

Main effects of habitat and season:

Green-winged teal were frequently observed feeding in both flooded rice fields and flooded wetlands. Time spent feeding by teal in this study was similar to that reported by Gaston and Nasci (1994) but differs from other studies (Quinlan and Baldassarre 1984, Rave and Baldassarre 1989). Habitat had a significant effect on courtship activities of green-winged teal. Courting parties occurred more frequently and were larger in flooded rice than in moist-soil wetlands. The openness of flooded agricultural fields may have facilitated locating potential mates and provided

unobstructed view of displays. Conversely, the levee system of the moist-soil complex inhibited groups of teal in each wetland from observing one another. In addition, since metabolizable energy values of agricultural grains are high (Reinecke et al. 1989), it is possible energetic needs may be met quicker while foraging on this food type, thus more time may be allocated to other activities such as courtship.

Time-activity budget data of non-breeding northern shovelers are more limited. Several studies suggest that this species uses deeper aquatic habitats than several other dabbling duck species, and observations are often associated with abundant aquatic vegetation during the non-breeding period (Fredrickson and Taylor 1982, Tietje and Teer 1988). On the Yazoo refuge, northern shovelers used such habitats (Maul 1997); however, they were also observed frequently in flooded rice fields. Several activities of northern shovelers were different between flooded rice fields and moist-soil wetlands. They spent more time resting in flooded rice fields than in moist-soil wetlands. In addition, agonistic activities of shovelers, although less than 1% of the their time budget, were influenced by habitat and season. Aggressive behavior may be associated with competition for food resources (Paulus 1983) and pair status (Hepp and Hair 1984). Peak pairing activity of shovelers likely occurred during December and January (Hepp and Hair 1983). Aggressive male-male interactions occur frequently during peak pairing and paired ducks are often dominant to unpaired individuals (Hepp and Hair 1984). The elevated levels of agonistic behavior during mid-winter (Dec-Jan) have been related to the intense competition between males for mates. After pair bonds have formed, agonistic activity is expected to diminish as attempts by unpaired males to disturb established bonds are often unsuccessful (Hepp and Hair 1983).

Mallards allocated more of their time to feeding in moist-soil wetlands than flooded rice, likely a result of energetic needs met more quickly while foraging on high energy foods. The percentage of time mallards fed in both habitat types was greater than that of mallards wintering in Alabama impoundments and river sites (Turnbull and Baldassarre 1987) and field feeding mallards in Nebraska (Jorde et al. 1984). However, percent feeding time was similar to foraging data of breeding mallards observed in Manitoba (Titman 1981). Percentage of time mallards were observed resting in moist-soil wetlands was similar to that of mallards studied in Nebraska (Jorde et al. 1984). In the present study, mallards rested more in flooded rice than they did in moist-soil wetlands which may be related to the greater percentage of time allocated to feeding in moist-soil wetlands by this species. Mallards used rice fields in small numbers during late winter, often in pairs or groups of pairs. Most mallards were dispersed throughout the area during this period and observations suggest many used both agricultural fields outside the Yazoo NWR and forested wetlands within the refuge.

Differences of feeding and resting activities of gadwall between habitats are most likely associated with diet. Gadwall feed almost exclusively on aquatic plants and filamentous algae (Bellrose 1980). Although less nutritious than seeds, grains, and animal matter (Sugden 1973), aquatic plants and algae were preferred by non-breeding gadwall in Louisiana (Paulus 1982). Gadwall eventually meet their nutritional demands by increasing food intake (Paulus 1982); thus, waterfowl foraging on foods of high nutrient content, such as agricultural grains, usually spend the least amount of time feeding (Paulus 1988).

Feeding patterns in moist-soil wetlands were similar to those reported in esturarine marshes in Louisiana (Paulus 1984), particularly between seasons. Effects of food type may be reflected by the greater percentage of time gadwall fed in moist-soil habitats (77%) as compared to rice fields (52%). Gadwall resting activities were also different between habitats with less time spent resting in moist-soil wetlands than flooded rice, indicating that flooded agricultural habitats may be important to gadwall as a resting location.

During late winter, gadwall in flooded rice usually remained throughout the entire diurnal period and possibly throughout the night, similar to observations of gadwall in Louisiana marshes by Paulus (1984). Flooded rice fields apparently afforded availability of high energy foods and a suitable resting site for gadwall. During late winter, as temperatures increased, algae was detected in many areas of flooded rice fields. Perhaps consumption of both algae and rice was sufficient to meet nutritional and energetic demands of gadwall. Interestingly, a habitat effect was detected on agonistic behaviors, fighting less in flooded rice than moist-soil wetlands.

Season by Habitat Interactions:

Rave and Baldassarre (1989) did not find a significant month by habitat interaction for courtship activity of green-winged teal; however, their study focused on Louisiana marsh habitat. The significant interaction between season and habitat type for courtship in green-winged teal during our study suggests that flooded rice fields and moist-soil wetlands provide for different requirements of these ducks during similar times of the winter. In addition, the role of flooded rice fields for green-winged teal courtship activities changed over time from mid-winter to late winter, possibly a result of

an increase of the proportion of paired individuals in the population. As more females pair, frequency of courtship behavior decreases (Hepp and Hair 1983). The temporal effects on courtship activities of green-winged teal detected during this study correspond with timing of pair bond formation (Hepp and Hair 1983).

A month by habitat interaction was found for alert activities of northern shovelers. Disturbance of shovelers by northern harriers, *Circus cyaneus*, was more common during mid-winter in moist-soil wetlands than flooded rice. Harrier activity in conjunction with shoveler use of deeper and more open areas of wetlands, probably affected the dynamics of alert behavior observed during the study. Harriers were observed hunting over flooded rice; however, their hunting effort was concentrated toward large groups of green-winged teal, while and small groups and pairs of shovelers were flushed less frequently. In addition, hunting pressure and vehicle disturbance may have also influenced alert activities of shovelers. Although duck hunting was not permitted on the Yazoo NWR, private lands adjacent to the moist-soil wetlands were hunted during mid-winter. As a result of deer season on the refuge, vehicle use on roads located adjacent to these wetlands was elevated.

A month by habitat interaction effect was detected for feeding, resting and preening activities of mallards. Percentage of time feeding in moist-soil wetlands and flooded rice were similar during mid-winter, but feeding time was greater in moist-soil wetlands than flooded rice during late winter. Mallards may have elevated feeding levels in moist-soil wetlands to acquire protein from invertebrate foods needed for molt (Heitmeyer 1988). Lack of sufficient protein levels may delay and lengthen prebasic molt in female mallards (Richardson and Kaminski 1992). Heitmeyer (1988) suggested

that female mallards relied on endogenous lipid stores for daily energy needs when increasing intake of foods high in protein such as invertebrates. Feeding patterns observed in this study reflect such a shift. Mallards decreased time feeding in a habitat containing high energy foods (flooded rice) and increased time feeding in a habitat (moist-soil wetlands) likely to offer foods of higher protein content (invertebrates) (Fredrickson and Taylor 1982).

Resting activities of mallards in both habitats was related to feeding activities. Foraging efficiency usually increases when consuming high energy foods (Baldassarre and Bolen 1984), affording more time for other activities. In mid-winter, percent time feeding was similar between habitats and consequently resting was also similar between habitats. However, during late winter percent time resting in moist-soil habitat decreased when feeding time was elevated. Conversely, resting time was elevated in flooded rice during late winter when percentage of time feeding was lower.

A habitat by season interaction was also detected for mallard preening activities. The function of each habitat type as a potential site for comfort and preening activities may have differed between seasons. Mallards spent more time preening in moist-soil in mid-winter and more time preening in rice fields during late winter and may be inversely related to feeding levels.

An interaction effect of habitat type and time of day was detected on locomotory activities of mallards. Movement was greater during morning in rice fields and decreased during mid-day and late afternoon. This morning movement likely reflected arrival to feeding sites and initial sampling of sections of fields to locate concentrated food sources.

Time spent feeding by gadwall was greater in moist-soil wetlands than flooded rice during early winter. In late winter, feeding levels dropped slightly in moist-soil wetlands and increased in flooded rice. During late winter, water had persisted on fields for two months or more and temperatures began to increase. Both of these factors promoted some natural vegetative growth, such as grasses at the water-field interface as well as algae blooms. These are potential food sources for gadwall and may have influenced the observed changes in foraging activity; however, gut contents of gadwall were not studied thus this, suggestion is largely speculative.

Environmental and Biological Variables:

Positive correlation was detected between percentage of time spent feeding by green-winged teal and the percentage of teal present in the flock. However, feeding activities were not related to flock size, suggesting that teal responded to the variability in the numbers of conspecifics but not the variability in the total number of ducks present within the habitat. Green-winged teal preferred to feed in groups containing more conspecifics, possibly taking advantage of the greater number of teal in order to locate concentrated food resources more efficiently. This suggestion is also supported by the negative correlation between movement of teal (locomotion) and the percentage of conspecifics, and number of conspecifics; suggesting more time was spent searching within or among habitats by smaller groups of ducks. Conversely, preening activities were positively related to flock size but not the number of conspecifics. Preening activities were positively correlated to temperature. As temperature increases, energetic demands are lower and require less feeding time therfore, more time could be allocated to other activities.

We observed a positive correlation of percent time resting by northern shovelers and temperature and light intensity, similar to that reported by Gaston and Nasci (1988). This relationship is likely a result of a decrease in energetic demands, thus less feeding time, as temperatures increase. Flock size, percentage of shovelers within the flock, and the total number of shovelers were also correlated with several activities, indicating social effects on behaviors. Percentage of time resting was positively correlated with flock size and number of shovelers while percent time feeding was negatively correlated with the percent composition of shovelers within the flock and the total number of shovelers in the habitat. It may have been advantageous for shovelers to rest gregariously for safety while preferring to feed in smaller groups to optimize foraging efficiency.

Courtship activities of northern shovelers were positively correlated with the number of shovelers present. Often, unpaired males were observed in the large aggregations of shovelers. Peak activity of northern shoveler pair bonding occurs later than mallards and gadwall, with most bonds forming in February (Hepp and Hair 1983). Northern shoveler data collected during this study occurred during the bonding period.

Percentage of time spent resting by mallards was negatively correlated with the total number of mallards present in the habitat. Although not significant, mallard feeding time was positively correlated with the total number of mallards present in the habitat. Mallards appeared to use a strategy of feeding in large concentrations while preferring to rest in smaller groups or pairs.

Alert activities of gadwall were positively related to the percentage of gadwall in the flock in flooded rice, suggesting a response to the number of conspecifics present.

Greater numbers may have increased the chance of a threat of unmated males on gadwall that were already paired or perhaps larger flocks elevated frequency of predation by northern harriers. Consistently, all species had a negative relationship between temperature and locomotion. During mid-winter, ducks often moved within and between habitats and subsequently in late winter, movement declined.

Conclusions

The effects of flooded agricultural fields and moist-soil wetlands on activity budgets of dabbling ducks are presented. Waterfowl react differently to each habitat type and the significant interaction effects indicate that the role of each habitat in the non-breeding waterfowl community changes over time. In addition, characteristics of these habitats such as flooded area and water depth may influence variables such as species composition and flock sizes which, in turn, have potential effects on how waterfowl use these habitats.

The potential of privately owned agricultural land in the Mississippi Delta to provide wetland habitat for non breeding waterfowl is great. Flooding agricultural fields, which requires minimal effort, simultaneously provides habitat for waterfowl and benefits such as soil erosion control, nutrient retention, and indirect cost saving from reduced herbicide application to the farmer.

Typically, non-breeding waterfowl use a system of habitats consisting of a resting area associated with several feeding sites (Tamisier 1979). For some species of waterfowl, feeding areas often consist of flooded agricultural fields. By maintaining sufficient water levels on harvested fields, habitats are made available to waterfowl and are incorporated into the system described by Tamisier (1979). This management

technique may be of greatest value in close proximity to protected areas, such as within the periphery of National Wildlife Refuges and Waterfowl Management Areas.

Agricultural land is a prominent landscape feature in most of the Mississippi Alluvial Valley and is extensively used by waterfowl, thus waterfowl activity data comparing flooded cropland with non-agricultural moist-soil areas is of importance. Thus, results from this study show that there are several main effects of habitat type and season on activity budgets of non-breeding waterfowl. Being that the role of a habitat may not remain constant from mid winter to late winter suggests that management of these areas should be flexible during the non-breeding period. It may be most beneficial to manage similar habitats with variability. Temporally, agricultural fields should be flooded in a staggered fashion. This may allow optimal availability of food resources over time. Spatially within a field, providing variation in flooded area may benefit species by indirectly providing variability in social factors such as flock size and numbers of conspecifics. Spatially within the landscape, flooding efforts should be concentrated around large protected areas containing non-agricultural habitats. However, these efforts should not be restricted as flooded fields acting as stop-over points along migration routes may be just as important to waterfowl.

Suggested future directions of research and management suggestions are to: (1) provide a diversity of habitat types for non-breeding waterfowl populations, (2) test for spatial effects on waterfowl habitat use such as recording time-activity budget data from flooded agricultural sites varying in distance from National Wildlife Refuges, and (3) not only incorporate more private landowners to seasonally flood agricultural fields but organize landowner effort into a waterfowl management network.

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LITERATURE CITED

Altmann, J. 1974. Observational study of behavior: sampling methods. Behaviour 49:227-267.

American Public Health Association 1992. Standard methods for the examination of water and wastewater. APHA, Washington, D. C.

Baldassarre, G. A., R. J. Whyte, E. E.Quinlan, and E. G. Bolen. 1983. Dynamics and quality of waste corn available to postbreeding waterfowl in Texas. Wildl. Soc. Bull. 11:25-31.

Baldassarre, G. A. and E. G. Bolen. 1984. Field-feeding ecology of waterfowl wintering on the southern high plains of Texas. J. Wildl. Manage. 48:63-71.

Baldassarre, G. A., and E. G. Bolen. 1994. Waterfowl Ecology and Management. John Wiley and sons, inc., NY. 609pp.

Beal, E. O. 1977. A manual of marsh and aquatic vascular plants of North Carolina. North Carolina Agricultural Exp. Stn. Tech. Bull. 247. 298pp.

Bellrose, F. C. 1980. Ducks, Geese, and Swans of North America. Third ed. Stackpole Books, Harrisburg, Pennsylvania. 540 pp.

Dell, D. A., R. H. Chabreck, P. M. McKenzie, and R. P. Martin. 1987. Wintering waterfowl and their habitats in Northeastern Louisiana. Research Report No. 12. School of Forestry, Wildlife, and Fisheries Louisiana Agricultural Experiment Station Louisiana State University Agricultural Center, Baton Rouge.

Delnicki, D. and K. J. Reinecke. 1986. Mid-winter food use and body weights of mallards and wood ducks in Mississippi. J. Wildl. Mange. 50:43-51.

Forsythe, S. W. 1985. The protection of bottomland hardwood wetlands of the lower Mississippi Valley. Transactions of the North American Wildlife and Natural Resources Conference 50:566-572.

Fredrickson, L. H. and F. A. Reid. 1988. Nutritional values of waterfowl foods. U.S. Fish and Wildlife leaflet 13.1.1. 6pp.

Fredrickson, L. H. and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. U.S. Fish and Wildl. Serv. Resour. Publ. 148. 29 pp.

Gaston, G. R. and J. C. Nasci. 1988. Activity budgets of wintering waterfowl on Rockefeller Refuge. Final report to Louisiana Board of Regents, Research and Development Program. McNeese State University, Lake Charles, LA.

Gaston, G. R. and J. C. Nasci. 1989. Diurnal time-activity budgets of nonbreeding gadwalls (*Anas strepera*) in Louisiana. Proc. Louisiana Acad. Sci. 52:43-54.

Gaston, G. R. and J. C. Nasci. 1994. Behavioral ecology of two teal species (blue-winged teal, *Anas discors*, and green-winged teal, *Anas crecca*) overwintering in marshes of coastal Louisiana, USA. Gulf Research Reports 9:39-48.

Heitmeyer, M. E. 1988. Body composition of female mallards in winter in relation to annual cycle events. Condor 90:669-680.

Hepp, G. R. and J. D. Hair. 1983. Reproductive behavior and pairing chronology in wintering dabbling ducks. Wilson Bulletin 95:675-682.

Hepp, G. R. and J. D. Hair. 1984. Dominance in wintering waterfowl (Anatini): effects on distribution of sexes. Condor 86:251-257.

Jandel Scientific 1994. Sigmastat Statistical Software. San Rafael, California.

Jorde, D. G., G. L. Krapu, and R. D. Crawford. 1983. Feeding ecology of mallards wintering in Nebraska. J. Wildl. Manage. 47:1044-1053.

Jorde, D. G., G. L. Krapu, and R. D. Crawford. 1984. Effects of weather on habitat selection and behavior of mallards wintering in Nebraska. Condor 86:258-265.

LaGrange, T. G. and J. J. Dinsmore. 1989. Habitat use by mallards during spring migration through central Iowa. J. Wildl. Manage. 53:1076-1081.

Loesch, C. R., K. J. Reinecke and C. K. Baxter. 1994. Lower Mississippi Valley Joint Venture Evaluation Plan. North Amer. Waterfowl Manage. Plan, Vicksburg, Miss. 34pp.

Maul, J. D. 1997. Habitat associations and behavioral analysis of non-breeding waterfowl in the Mississippi Delta. M.S. Thesis, Univ. of Mississippi, University. 80pp.

Miller, M. R. 1985. Time budgets of northern pintails wintering in the Sacramento Valley, California. Wildfowl 36:53-64.

Miller, M. R. 1987. Fall and winter foods of Northern Pintails in the Sacramento Valley, California. J. Wildl. Manage. 51(2):405-414.

Milliken, G. A. and D. E. Johnson. 1984. Analysis of messy data, vol. 1. Designed experiments. Lifetime Learning Publications, London.

Paulus, S. L. 1982. Feeding ecology of gadwalls in Louisiana in winter. J. Wildl. Manage. 46:71-79.

Paulus, S. L. 1983. Dominance relations, resource use, and pairing chronology of gadwalls in winter. Auk 100:947-952.

Paulus, S. L. 1984. Activity budgets of nonbreeding gadwalls in Louisiana. J. Wildl. Manage. 48:371-380.

Paulus, S. L. 1988. Time-activity budgets of nonbreeding Anatidae: A reveiw. Pages 135-152 in M. Weller Ed. Waterfowl in Winter: a symp. Univ. Minnesota Press, Minneapolis.

Quinlan, E. E. and G. A. Baldassarre. 1984. Activity budgets of nonbreeding green-winged teal on Playa lakes in Texas. J. Wildl. Manage. 48:838-845.

Rave, D. P. and G. A. Baldassarre. 1989. Activity budget of green-winged teal wintering in coastal wetlands of Louisiana. J. Wildl. Manage. 53:753-759.

Rave, D. P. and C. L. Cordes. 1993. Time-activity budget of Norther pintails using nonhunted rice fields in Southwest Louisiana. J. Field Ornithol. 64(2):211-218.

Reinecke, K. J., R. M. Kaminski, D. J. Moorehead, J. D. Hodges and J. R. Nassar. 1989. Mississippi Alluvial Valley. Pages 203-247 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, eds. Habitat management for migrating and wintering waterfowl in North America. Texas Tech Univ. Press, Lubbock, TX.

Richardson, D. M. and R. M. Kaminski. 1992. Diet restriction, diet quality, and prebasic molt in female mallards. J. Wildl. Manage. 56(3):531-539

Ringelman, J. K. 1990. Managing agricultural foods for waterfowl. U.S. Fish and Wildlife Service leaflet 13.4.3. 6pp.

Shearer, L. A., B. J. Jahn and L. Lenz. 1969. Deterioration of duck foods when flooded. J. Wildl. Manage. 33(4):1012-1014.

SAS Institute Inc. 1985. SAS users guide: statistics. Fifth ed. SAS Institute Inc., Cary, North Carolina.

Sugden, L. G. 1973. Metabolizable energy of wild duck foods. Progress notes of Canadian Wildlife Service 35:1-4.

Tamisier, A. 1979. The functional units of wintering ducks: A spatial integration of their comfort and feeding requirements. Verh. orn. Ges. Bayern 23:229-238.

Thompson, J. D. and B. A. Baldassarre. 1991. Activity patterns of nearctic dabbling ducks wintering in Yucatan, Mexico. Auk 108:934-941.

Tietje, W. D. and J. G. Teer. 1988. Winter body condition of Northern shovelers on freshwater and saline habitats. Pages 353-376 in M. Weller Ed. Waterfowl in Winter. Univ. Minnesota Press, Minneapolis.

Titman, R. 1981. A time-activity budget for breeding Mallards (*Anas platyrhynchos*) in Manitoba. Canadian Field-Naturalist 95:266-271.

Turnbull, R. E. and G. A. Baldassarre. 1987. Activity budgets of mallards and American wigeon wintering in east-central Alabama. Wilson Bull. 99:457-464.

Weller, M. W. and B. D. J. Batt. 1988. Waterfowl in Winter: Past, present, and future. *in* Waterfowl in Winter: a symp. Pages 135-152, Weller, M., ed. Univ. Minnesota Press, Minneapolis.

Zar, J.H. 1984. Biostatistical Analysis. Prentice-Hall Inc., Englewood Cliffs, N.J. 620 pp.

Table 1. Water quality parameter means (±SD) of 5 flooded agricultural fields and 5 moist-soil wetlands during the period of January, 1996 to March, 1996 (YR1) and December, 1996 to March, 1997 (YR2).

	Agricultural Fields		Moist-soil Wetlands	
Parameter	YR 1	YR 2	YR 1	YR 2
pH	8.47 (0.46)	7.82 (0.61)	9.16 (0.43)	8.11 (0.52)
H2O Temp (C)	16.15 (6.83)	12.31 (6.76)	13.55 (8.29)	10.5 (6.21)
Dissolved O2 (mg/L)	1.87 (0.48)	11.08 (3.51)	1.79 (0.29)	12 (2.62)
Conductivity (mS/cm)	0.2 (0.09)	0.12 (0.06)	0.27 (0.11)	0.19 (0.07)
Salinity (0/00)	0.12 (0.04)	0.09 (0.04)	0.16 (0.05)	0.14 (0.05)
Total Solids (mg/L)	----	553.35 (759.36)	----	230.12 (76.33)
Dissolved Solids (mg/L)	----	107.18 (48.0)	----	141.52 (53.35)
Suspended Solids (mg/L)	----	446.18 (765.05)	----	88.6 (84.14)
Filtered Ortho-phosphates (mg/L)	0.04 (0.03)	0.04 (0.02)	0.11 (0.12)	0.06 (0.05)
Total Phosphorous (mg/L)	0.29 (0.18)	1.29 (3.06)	0.36 (0.20)	0.39 (0.40)
Ammonia (mg/L)	----	0.47 (1.06)	----	0.22 (0.26)
Nitrate (mg/L)	----	0.1 (0.10)	----	0.09 (0.07)
Chlorophyll (mg/L)	----	68.92 (58.49)	----	29.27 (28.14)
Coliforms (cfu/100mL)	----	8596.1 (29711.13)	----	410.55 (611.32)
Enterococci (cfu/100mL)	----	704.16 (1020.09)	----	194.64 (403.66)

Table 2. Time activity budgets of green-winged teal observed in rice fields and moist-soil impoundments from December 1995 to March 1997.

Habitat	Time of year (Season)	Time of day	Behavioral Activities (percent of time)							n
			Feeding	Locomotion	Resting	Preening	Alert	Courtship	Agonistic	
Moist-soil Impoundment	Mid-winter	Morning	81.3	7.3	6.7	4.3	0.3	0.0	0.1	3
		Mid-day	82.7	12.4	2.0	2.4	0.3	0.0	0.1	2
		Afternoon	54.1	20.6	14.8	10.2	0.2	0.0	0.1	2
	Late winter	Morning	87.9	8.7	0.6	0.9	0.9	0.7	0.3	3
		Mid-day	81.1	3.7	6.1	8.8	0.0	0.0	0.3	3
		Afternoon	83.1	5.9	5.7	4.8	0.3	0.0	0.3	2
Flooded Rice	Mid-winter	Morning	67.2	13.8	9.8	4.2	0.1	3.6	1.3	4
		Mid-day	71.2	10.0	12.5	2.6	0.2	3.2	0.2	4
		Afternoon	73.1	14.9	6.4	2.2	0.2	3.1	0.1	3
	Late winter	Morning	79.0	9.4	6.4	3.4	0.9	0.7	0.1	8
		Mid-day	69.5	12.7	12.2	3.9	0.5	0.8	0.3	8
		Afternoon	79.2	7.1	7.9	4.5	0.4	0.5	0.3	7

Table 3. Time activity budgets of northern shovelers observed in rice fields and moist-soil impoundments from December 1995 to March 1997.

			Behavioral Activities (percent of time)							
Habitat	Time of year (Season)	Time of day	Feeding	Locomotion	Resting	Preening	Alert	Courtship	Agonistic	n
Moist-soil Impoundment	Mid-winter	Morning	76.9	14.9	1.2	3.3	0.8	0.4	2.5	1
		Mid-day	96.2	2.4	0.0	0.9	0.5	0.0	0.0	1
		Afternoon	86.6	6.2	0.7	5.2	0.7	0.0	0.7	1
	Late winter	Morning	81.3	5.4	5.8	6.3	0.2	0.8	0.2	10
		Mid-day	69.5	7.2	12.5	10.2	0.1	0.2	0.3	6
		Afternoon	65.9	6.4	18.1	9.0	0.1	0.4	0.1	4
Flooded Rice	Mid-winter	Morning	65.3	12.7	12.5	9.5	0.0	0.0	0.0	2
		Mid-day	66.7	14.0	11.1	7.2	0.0	0.4	0.5	3
		Afternoon	75.6	8.4	10.6	5.1	0.1	0.2	0.0	3
	Late winter	Morning	72.0	13.6	7.1	6.2	0.6	0.3	0.2	8
		Mid-day	59.1	10.0	24.8	5.9	0.2	0.1	0.0	7
		Afternoon	66.9	8.4	16.9	7.2	0.5	0.1	0.1	7

Table 4. Time activity budgets of mallards observed in rice fields and moist-soil impoundments from December 1995 to March 1997.

			Behavioral Activities (percent of time)							
Habitat	Time of year (Season)	Time of day	Feeding	Locomotion	Resting	Preening	Alert	Courtship	Agonistic	n
Moist-soil Impoundment	Mid-winter	Morning	56.2	15.6	16.1	7.9	1.7	2.0	0.5	7
		Mid-day	61.9	13.9	16.4	5.7	1.3	0.2	0.6	4
		Afternoon	38.0	20.1	29.1	10.5	1.7	0.4	0.2	4
	Late winter	Morning	83.4	7.8	2.5	0.7	2.8	2.8	0.0	1
		Mid-day	82.6	9.3	7.3	0.7	0.0	0.0	0.0	2
		Afternoon	56.8	38.0	4.5	0.7	0.0	0.0	0.0	2
Flooded Rice	Mid-winter	Morning	39.6	28.6	24.0	4.5	1.7	1.4	0.2	3
		Mid-day	68.8	17.1	11.7	1.6	0.5	0.0	0.3	3
		Afternoon	82.4	6.7	7.1	3.3	0.0	0.0	0.5	1
	Late winter	Morning	41.1	14.7	37.2	5.9	1.1	0.0	0.0	3
		Mid-day	5.7	2.0	88.0	4.3	0.0	0.0	0.0	2
		Afternoon	11.8	1.5	75.0	11.4	0.4	0.0	0.0	2

Table 5. Time activity budgets of gadwalls observed in rice fields and moist-soil impoundments from December 1995 to March 1997.

			Behavioral Activities (percent of time)							
Habitat	Time of year (Season)	Time of day	Feeding	Locomotion	Resting	Preening	Alert	Courtship	Agonistic	n
Moist-soil Impoundment	Mid-winter	Morning	84.1	9.2	2.1	2.9	0.2	1.2	0.3	2
		Mid-day	84.4	10.5	2.2	1.9	0.6	0.5	0.0	2
		Afternoon	79.9	10.8	2.2	5.9	0.0	0.7	0.4	1
	Late winter	Morning	75.0	14.7	1.4	6.5	0.1	2.3	0.1	6
		Mid-day	77.5	11.8	1.7	8.3	0.1	0.6	0.1	5
		Afternoon	70.9	19.0	1.6	6.1	0.1	2.2	0.3	5
Flooded Rice	Mid-winter	Morning	28.3	37.0	25.6	1.5	1.9	5.7	0.0	2
		Mid-day	42.1	19.3	16.2	20.1	0.0	2.0	0.3	3
		Afternoon	24.3	37.8	31.1	4.1	0.0	2.7	0.0	1
	Late winter	Morning	70.5	11.4	8.0	6.5	2.1	1.5	0.0	5
		Mid-day	49.5	10.8	32.5	5.8	1.2	0.2	0.0	4
		Afternoon	58.2	6.6	24.4	9.6	0.9	0.4	0.0	3

Table 6. Results of the three-way analysis of variance testing effects of D (time of day), S (season), H (habitat), and their interaction on waterfowl time-activity budgets recorded at the Yazoo NWR, Washington Co., MS from December, 1995 to March, 1997. Only P-values less than 0.05 are included in the table.

			Behavioral Activity						
Species	N	Treatment	Feeding	Locomotion	Resting	Preening	Alert	Courtship	Agonistic
Green-winged Teal	49	D							
		S							
		H						0.0001	
		S*D							
		H*D							
		H*S						0.016	
		H*S*D							
Northern Shoveler	53	D							
		S							0.023
		H			0.045				0.0007
		S*D							
		H*D							0.015
		H*S					0.0006		
		H*S*D							0.0001
Mallard	34	D					0.019	0.016	
		S			0.025				0.004
		H	0.017		0.0001				
		S*D							
		H*D		0.045					
		H*S	0.001		0.0001	0.0001			
		H*S*D							
Gadwall	39	D							
		S							
		H	0.0003		0.0001				0.021
		S*D							
		H*D							0.037
		H*S	0.034						
		H*S*D							

Table 7. Percent time spent in activities by four species of non-breeding dabbling ducks in moist-soil wetlands and flooded rice from December, 1995 to March, 1997.

		Behavioral Activities (percent of time)							
Species	Habitat	Feeding	Locomotion	Resting	Preening	Alert	Courtship	Agonistic	n
Green-winged	Moist-soil	79.4	9.1	5.7	5.1	0.3	0.1 A	0.2	15
Teal	Rice	74.0	10.8	9.2	3.7	0.5	1.5 B	0.3	34
Northern	Moist-soil	76.2	6.3	9.0 A	7.4	0.2	0.5	0.3 A	23
Shoveler	Rice	67.2	11.0	14.6 B	6.6	0.3	0.1	0.1 B	30
Mallard	Moist-soil	57.7 A	17.4	16.0 A	6.2	1.4	1.0	0.3	20
	Rice	40.4 B	13.9	39.4 B	5.0	0.7	0.3	0.1	14
Gadwall	Moist-soil	76.6 A	13.9	1.7 A	6.0	0.1	1.5	0.2 A	21
	Rice	51.8 B	16.1	20.8 B	8.4	1.2	1.6	0.0 B	18

A, B - Means with different letters are significantly different between habitat type within each activity for each species ($P<0.05$)

Table 8. Percent time spent in activities by four species of non-breeding dabbling ducks during mid-winter and late winter from December, 1995 to March, 1997.

		Behavioral Activities (percent of time)							
Species	Season	Feeding	Locomotion	Resting	Preening	Alert	Courtship	Agonistic	n
Green-winged	Mid-winter	71.7	12.7	9.0	4.0	0.2	2.0	0.4	18
Teal	Late winter	77.9	8.9	7.6	4.2	0.6	0.6	0.2	31
Northern	Mid-winter	74.3	10.5	8.4	6.0	0.2	0.2	0.4 A	11
Shoveler	Late winter	70.3	8.6	13.2	7.2	0.3	0.3	0.2 B	42
Mallard	Mid-winter	54.6	17.7	18.6 A	6.4	1.4	0.9	0.4 A	22
	Late winter	43.4	12.8	38.6 B	4.4	0.6	0.2	0.0 B	12
Gadwall	Mid-winter	56.7	20.0	12.9	7.5	0.5	2.2	0.2	11
	Late winter	68.5	12.9	9.6	7.0	0.7	1.3	0.1	28

A, B - Means with different letters are significantly different between months within each activity for each species ($P<0.05$)

Table 9. Pearson correlation coefficients of environmental and biological variables and activities of four species of dabbling ducks in flooded rice fields at the Yazoo NWR from December 1995 to March 1997

		Behavioral Activity (Percentage of Time)						
Species	Variable	Feeding	Locomotion	Resting	Comfort	Alert	Courtship	Agonistic
Green-winged Teal	Cloud Cover	0.045	0.180	-0.173	-0.084	-0.063	0.032	-0.328
	Light Intensity	0.018	-0.409 *	0.300	0.234	0.057	-0.068	0.053
	Temperature	0.010	-0.449 *	0.344	0.546 **	0.271	-0.211	-0.047
	Flock Size	0.055	-0.449 **	0.332	0.472 **	0.260	-0.170	-0.039
	% of Teal	0.487 **	-0.352 *	-0.205	-0.153	0.267	-0.081	0.102
	Number of Teal	0.263	-0.485 **	0.178	0.187	0.264	-0.207	-0.030
Northern Shoveler	Cloud Cover	0.136	0.046	-0.180	-0.150	0.310	0.261	0.224
	Light Intensity	-0.352	-0.292	0.495 **	0.087	-0.250	-0.142	-0.223
	Temperature	-0.171	-0.727 ***	0.528 **	0.102	-0.092	0.034	-0.430 *
	Flock Size	-0.151	-0.507 **	0.410 *	0.049	0.176	0.053	-0.173
	% of Shovelers	-0.421 *	-0.023	0.375 *	0.241	-0.047	0.761 ***	0.146
	Number of Shovelers	-0.447 *	-0.397 *	0.598 ***	0.227	0.161	0.489 **	-0.034
Mallard	Cloud Cover	-0.346	0.140	0.191	0.009	0.146	0.218	-0.049
	Light Intensity	0.098	0.029	-0.056	-0.014	-0.225	-0.024	0.298
	Temperature	-0.222	-0.431	0.424	0.421	-0.101	-0.434	-0.222
	Flock Size	0.002	-0.085	0.031	0.394	-0.252	0.110	-0.178
	% of Mallards	-0.007	-0.115	0.005	-0.159	-0.032	0.014	0.325
	Number of Mallards	0.446	0.063	-0.509 *	0.008	0.095	0.310	0.429
Gadwall	Cloud Cover	-0.090	-0.050	0.047	0.125	0.078	-0.070	——
	Light Intensity	0.099	-0.231	0.126	-0.010	-0.202	-0.167	——
	Temperature	0.355	-0.482 *	0.156	-0.048	0.158	-0.233	-0.222
	Flock Size	0.156	-0.288	0.167	-0.127	0.305	0.004	-0.022
	% of Gadwall	0.123	-0.253	0.135	-0.102	0.206 *	-0.473	-0.180
	Number of Gadwalls	0.226	-0.335	0.138	-0.182	0.354	-0.258	-0.139

* $P<0.05$
** $P<0.01$
*** $P<0.001$

FIGURES

Slotted-Board Riser Pipe

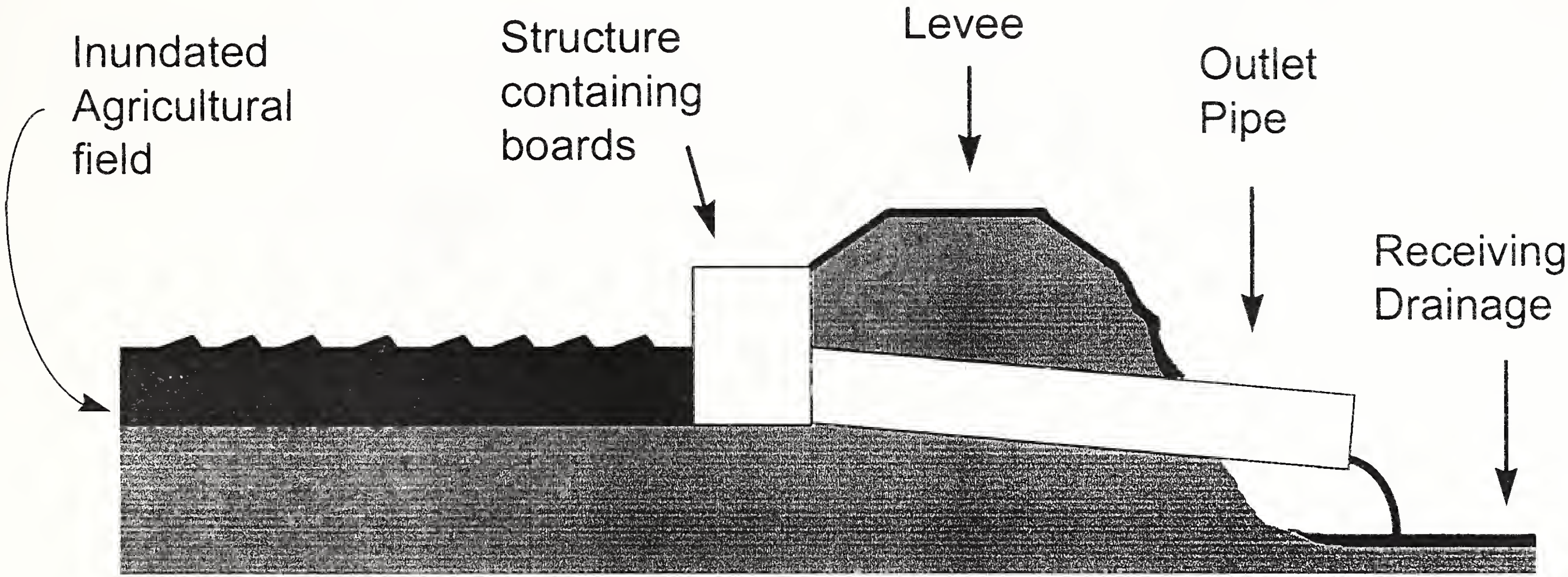

Figure 1. Schematic representing the cross section of a slotted-board riser pipe.

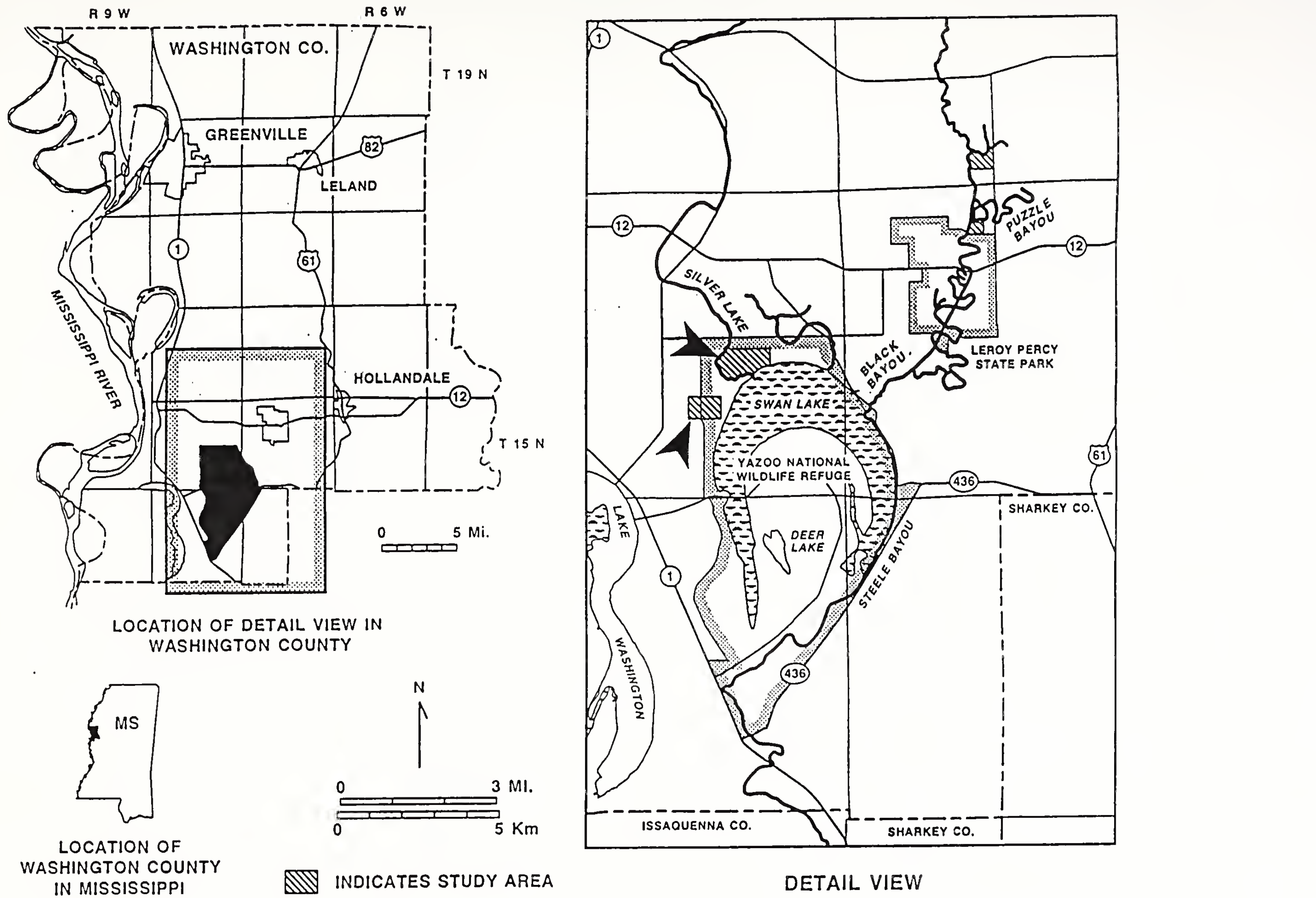

Figure 2 Schematic depicting the location of the study sites within the Yazoo National Wildlife Refuge and the location of the refuge within Washington Co., Mississippi. This figure was adapted from graphics created by Paul Mitchell at the University of Mississippi.

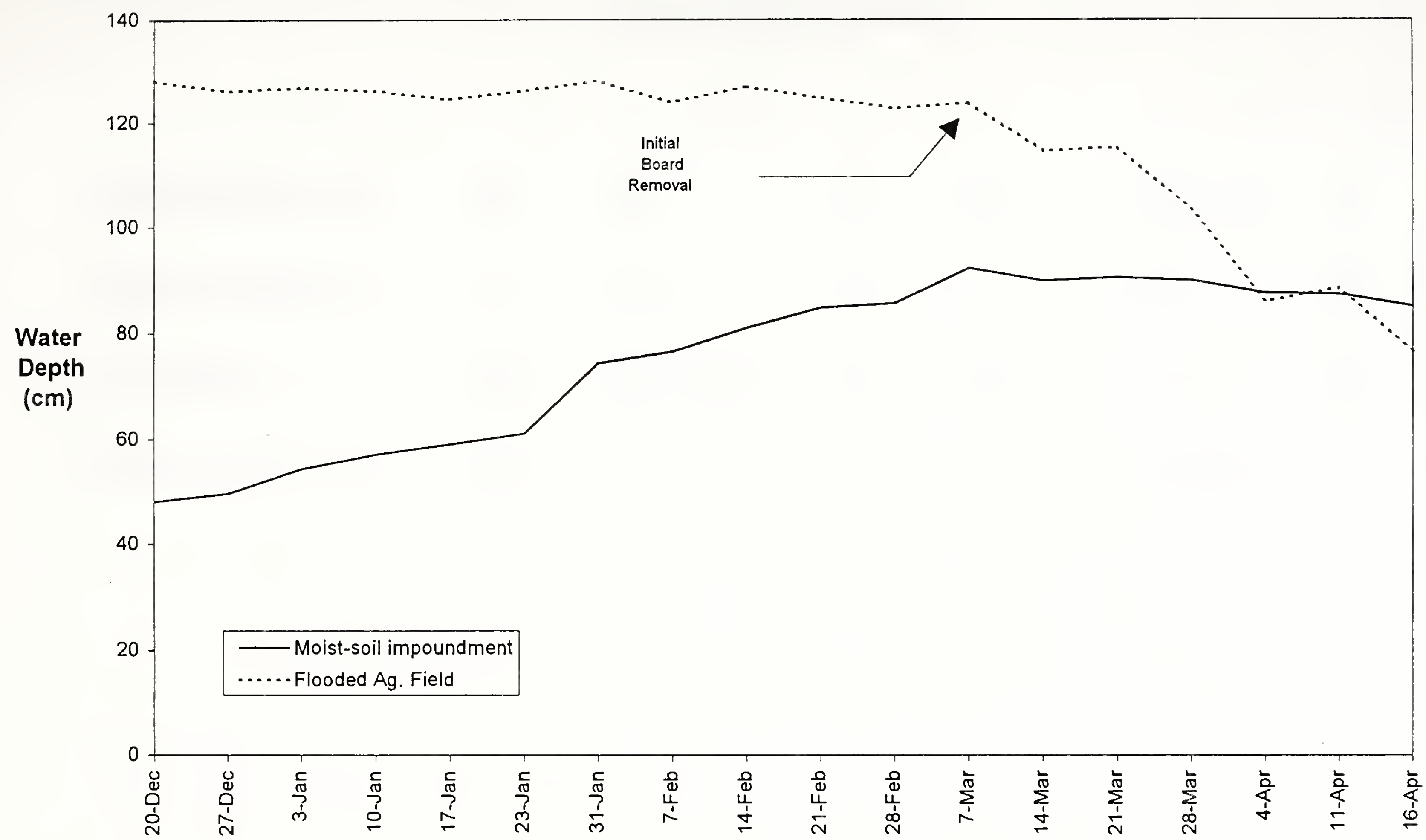

Figure 3. Water depth at two study sites during the period of 20 December, 1996 to 16 April, 1997. Stage recorders were positioned at the topographic low of each site.

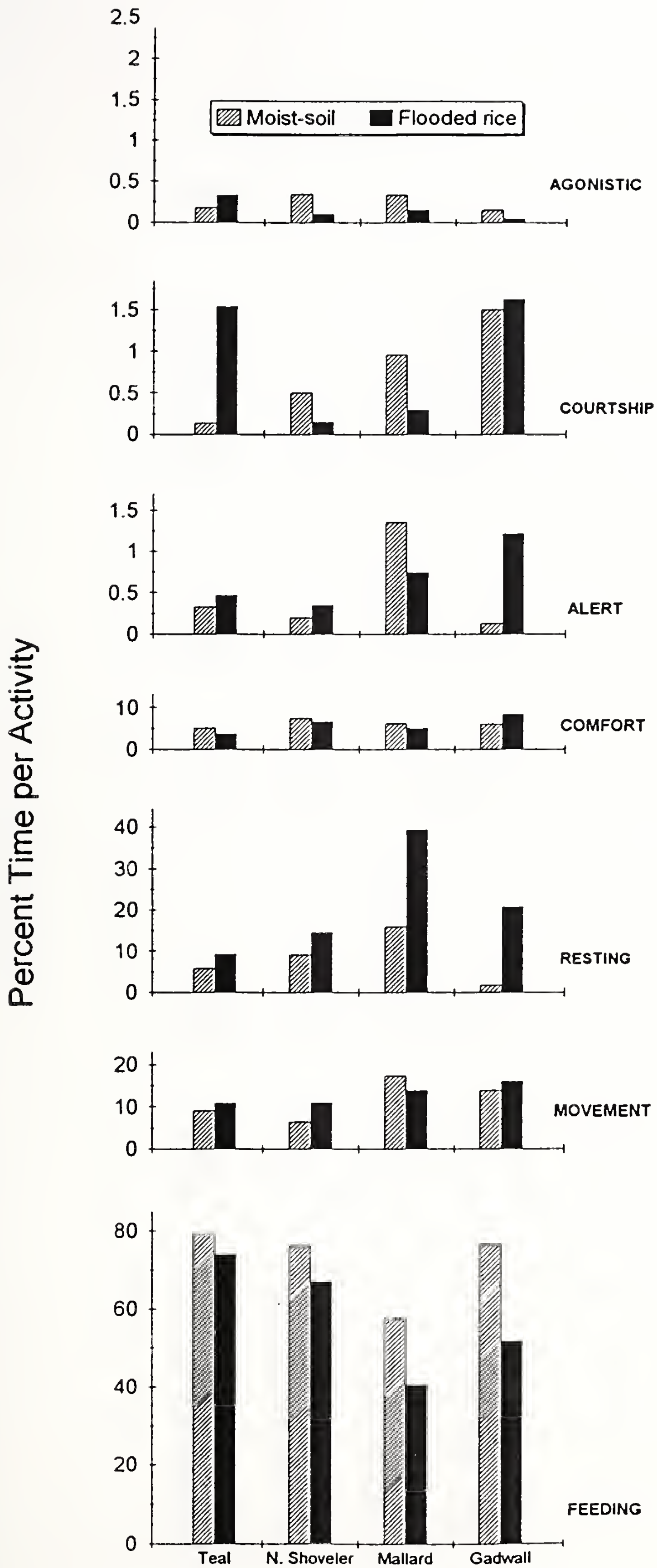

Figure 4. Activity budgets of four species of dabbling ducks by habitat type on the Yazoo NWR from December 1995 to March 1997. Bars shown are means for activities in moist-soil impoundments (crosshatched) and flooded post-harvested rice fields (solid). Note that the scale of the y-axis for alert, courtship, and agonistic activities is reduced.

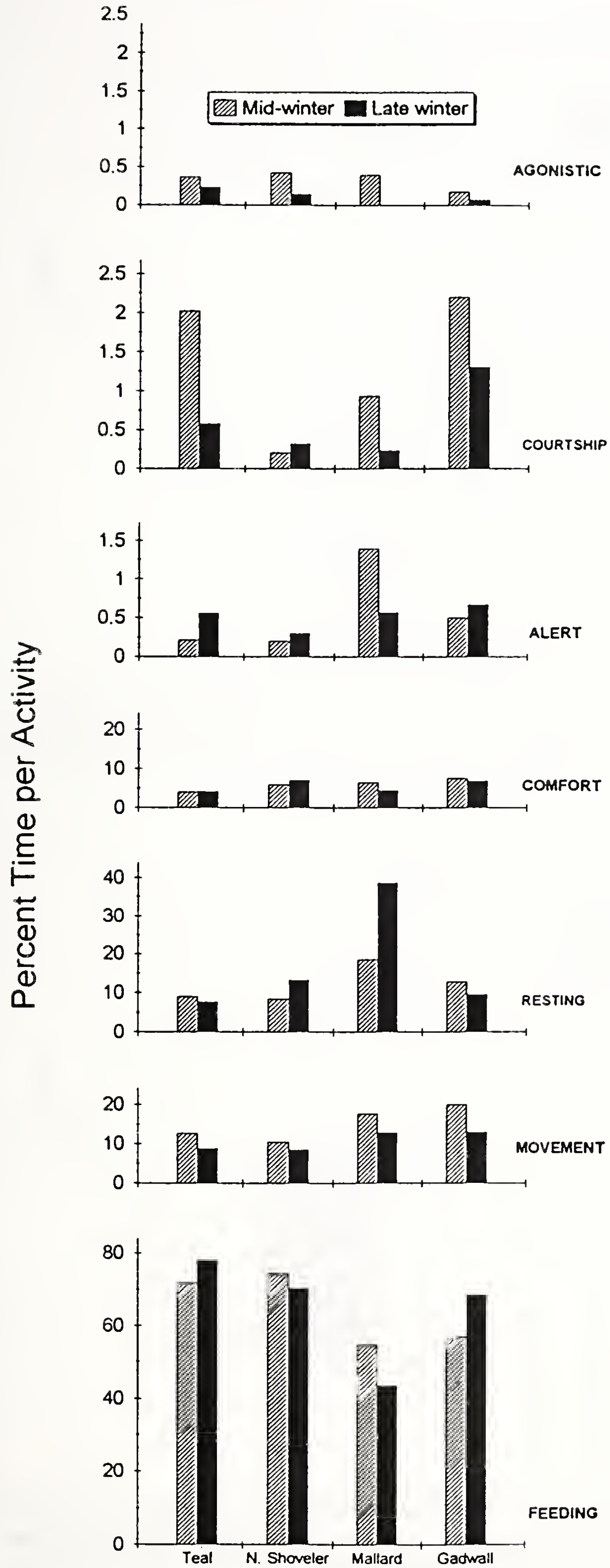

Figure 5. Activity budgets of four species of dabbling ducks by season on the Yazoo NWR from December 1995 to March 1997. Bars shown are means for activities in mid-winter (Dec-Jan) (crosshatched) and late winter (Feb-Mar) (solid). Note that the scale of the y-axis for alert, courtship, and agonistic activities is reduced.

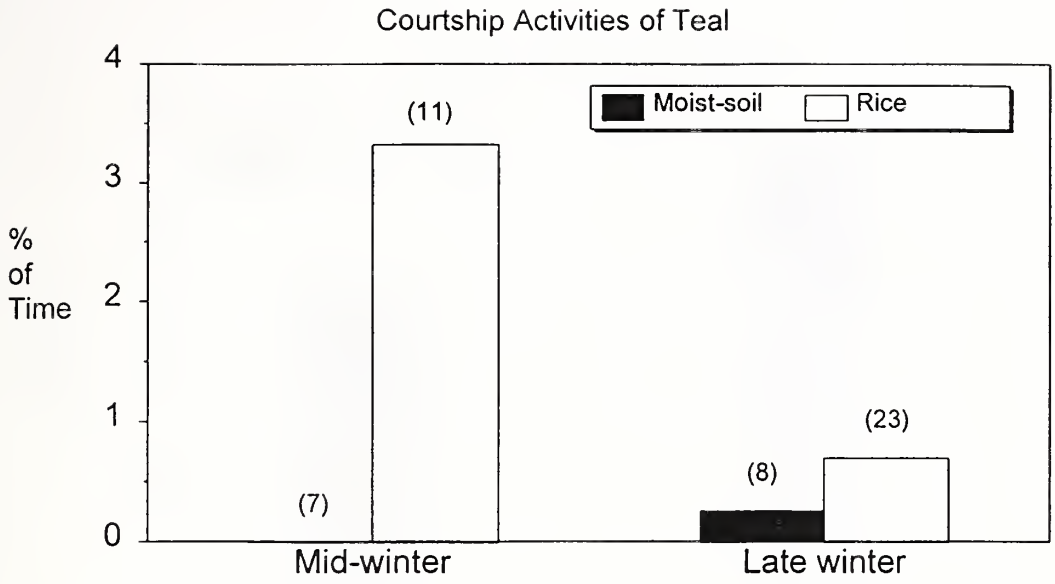

Figure 6. Graphical representation of the two-way interaction effect of season (mid-winter and late winter) and habitat (moist-soil and flooded rice) on the percentage of time spent courting by green-winged teal. Numbers in parentheses are sample sizes.

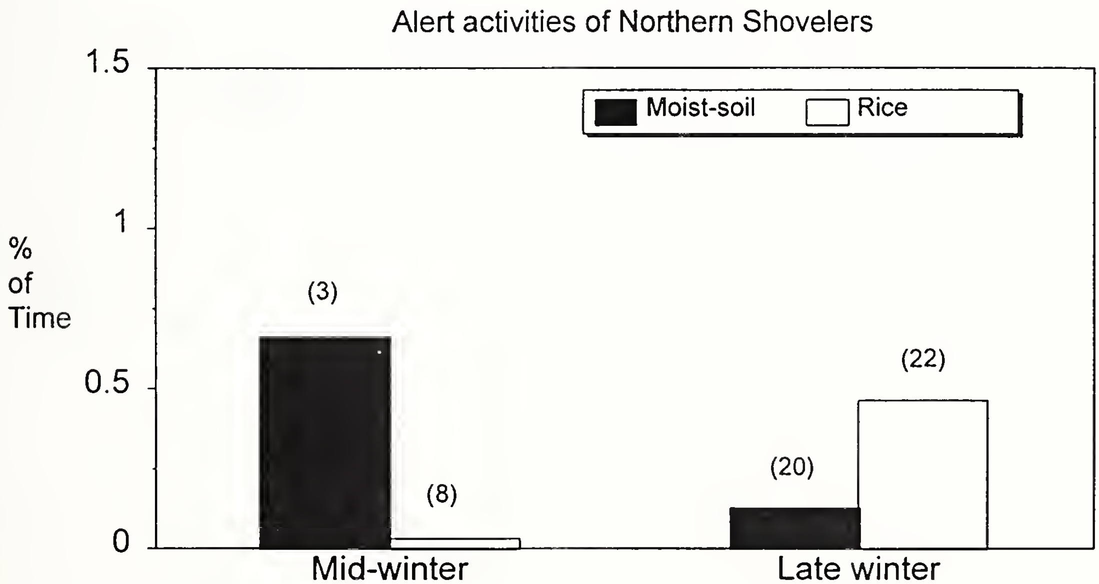

Figure 7. Graphical representation of the two-way interaction effect of season (mid-winter and late winter) and habitat (moist-soil and flooded rice) on the percentage of time spent alert by northern shovelers. Numbers in parentheses are sample sizes.

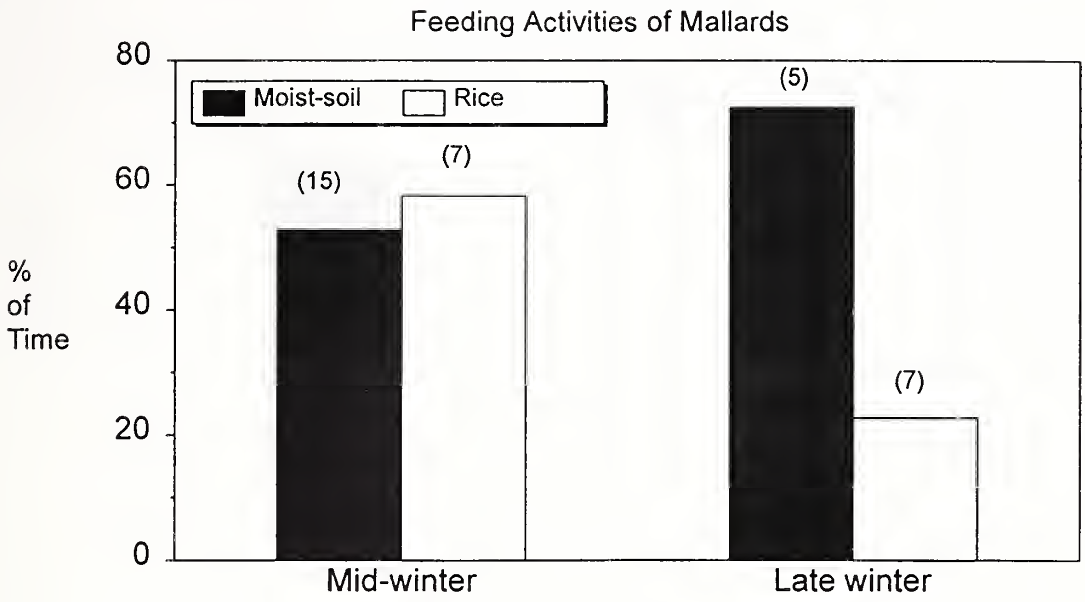

Figure 8. Graphical representation of the two-way interaction effect of season (mid-winter and late winter) and habitat (moist-soil and flooded rice) on the percentage of time spent feeding by mallards. Numbers in parentheses are sample sizes.

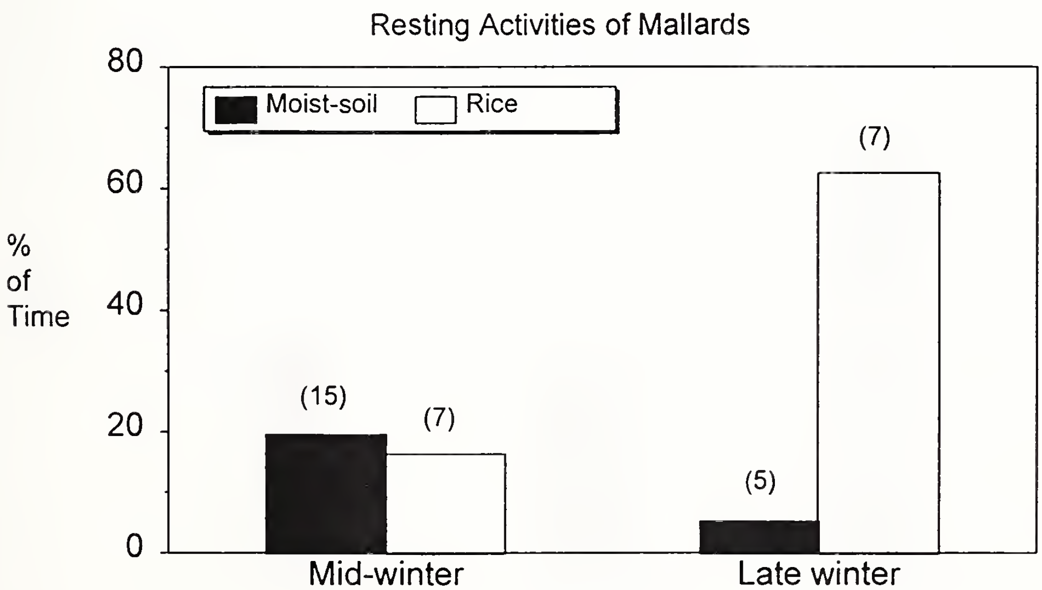

Figure 9. Graphical representation of the two-way interaction effect of season (mid-winter and late winter) and habitat (moist-soil and flooded rice) on the percentage of time spent resting by mallards. Numbers in parentheses are sample sizes.

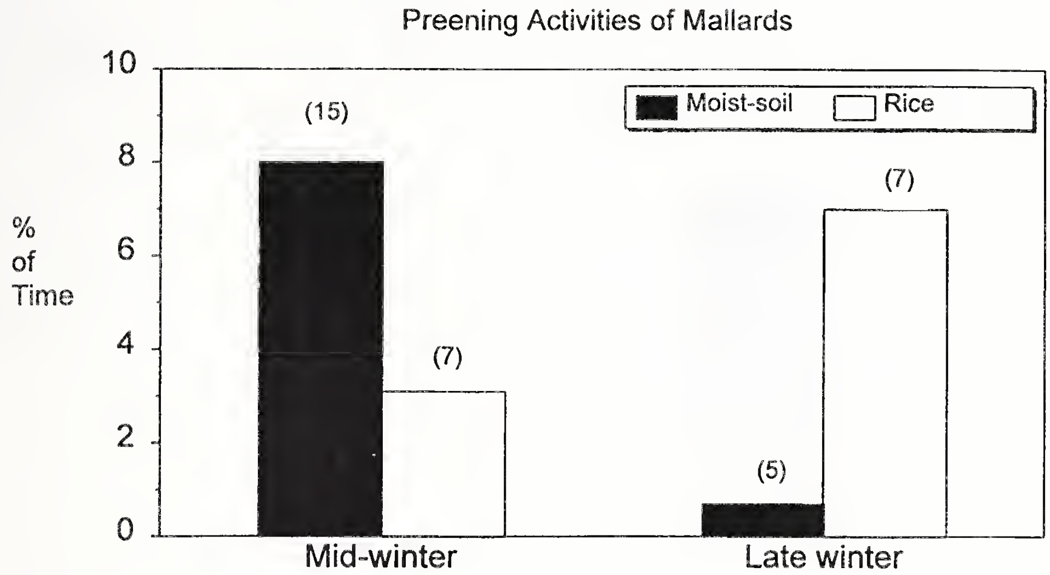

Figure 10. Graphical representation of the two-way interaction effect of season (mid-winter and late winter) and habitat (moist-soil and flooded rice) on the percentage of time spent preening by mallards. Numbers in parentheses are sample sizes.

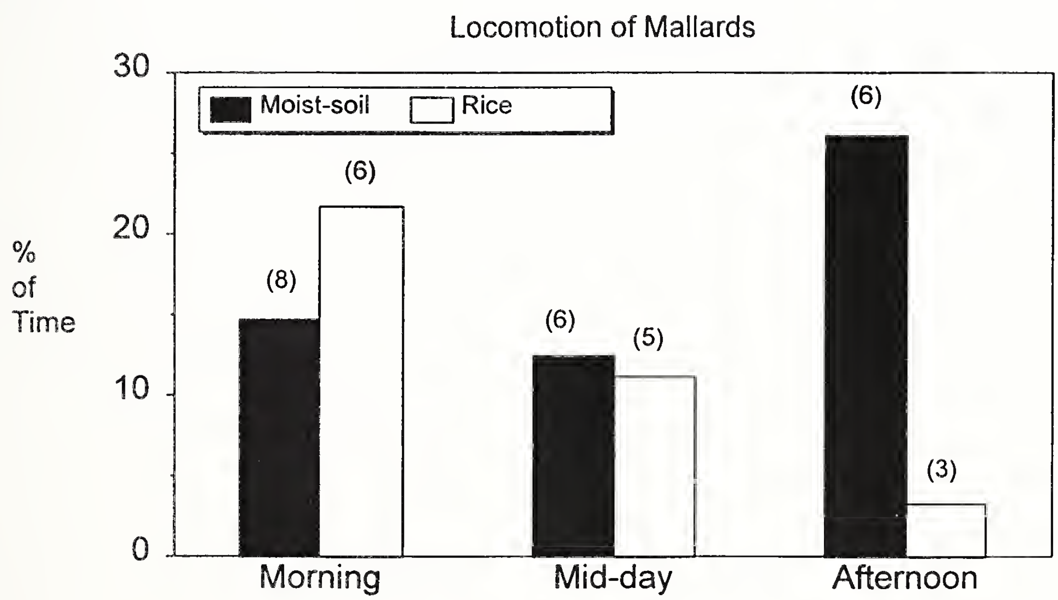

Figure 11. Graphical representation of the two-way interaction effect of time of day (morning, mid-day, late afternoon) and habitat (moist-soil and flooded rice) on the percentage of time spent moving by mallards. Numbers in parentheses are sample sizes.

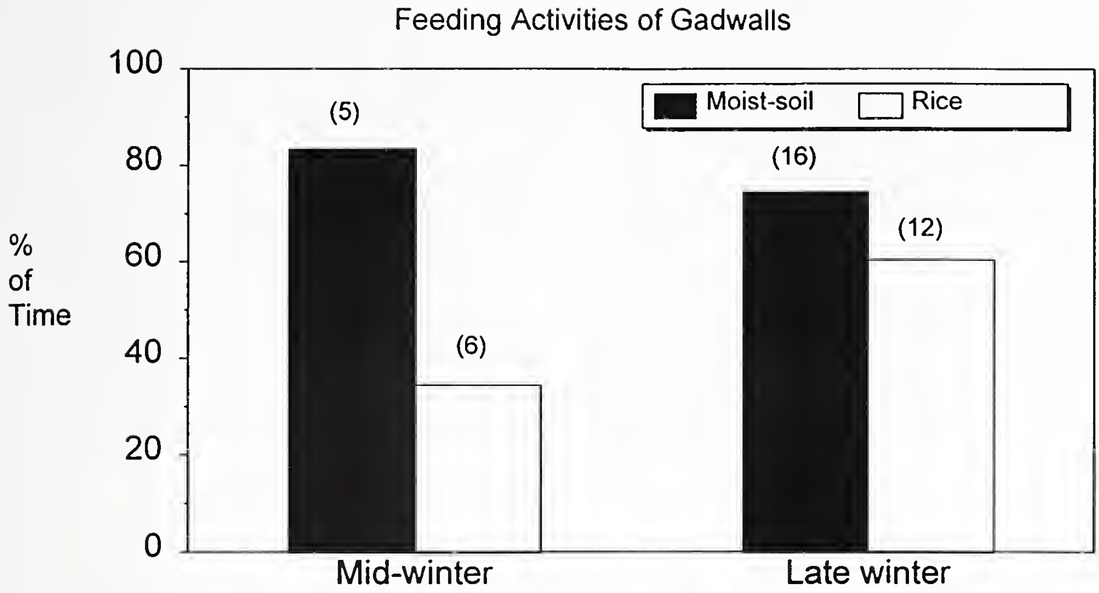

Figure 12. Graphical representation of the two-way interaction effect of season (mid-winter and late winter) and habitat (moist-soil and flooded rice) on the percentage of time spent feeding by gadwall. Numbers in parentheses are sample sizes.